6. COMPARISON WITH APPLICABLE STREAM WATER QUALITY CRITERIA

The grab samples collected in this study are compared to the “not to exceed” limits set to protect aquatic life. A detailed description of West Virginia’s stream water quality criteria is included in Attachment 1. There are ten applicable parameters that have stream limits set to protect aquatic life and have a maximum or minimum limit. They will be discussed in alphabetical order.

Only the results from the second laboratory are included in this comparison. Laboratory results for metals were more precise at the second laboratory than at the first according to the data from duplicate samples. There were fewer instances of contaminated blank samples in the data from the second laboratory (see Table 3). There were far fewer laboratory results rejected in the QA/QC review at the second laboratory than at the first (see Table 5).

6.1 Total Aluminum - Maximum 750 ug/L

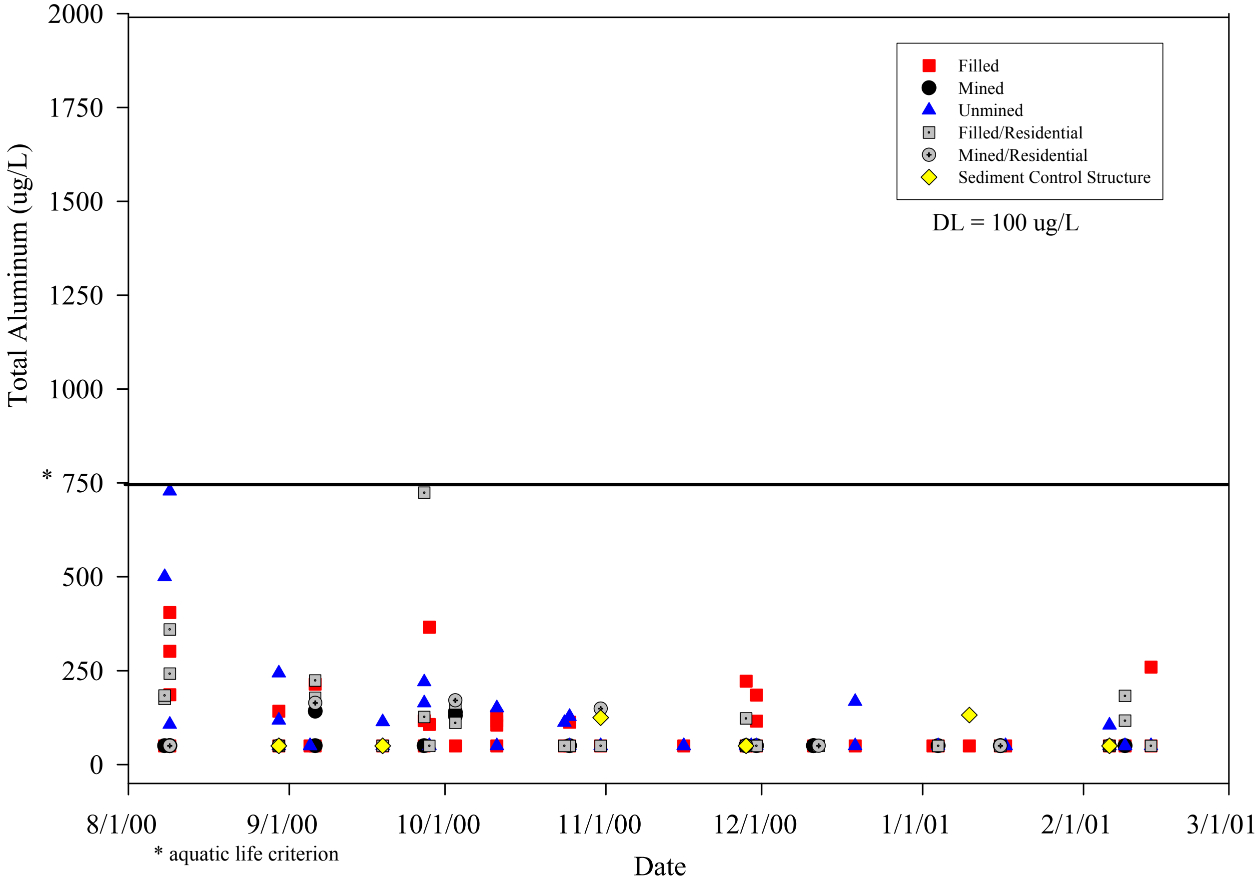
There were 213 samples for total aluminum sent to the second laboratory and one result was rejected in the QA/QC review resulting in 99.53 % completeness. The detection limit was 100 ug/L.

6.1.a Aluminum Concentration in Stream Samples

Aluminum was found in samples from all classes of sites and from sites spread across the study area but generally at concentrations below 250 ug/L. There were no sample results from the second laboratory that exceeded the stream criterion for aluminum Six samples collected 8/9/00 had higher concentrations of aluminum but they were flagged as estimates due to contamination of the blank The three values above 750 ug/L on that date are not considered as violations of the stream criterion since they were flagged as estimates.

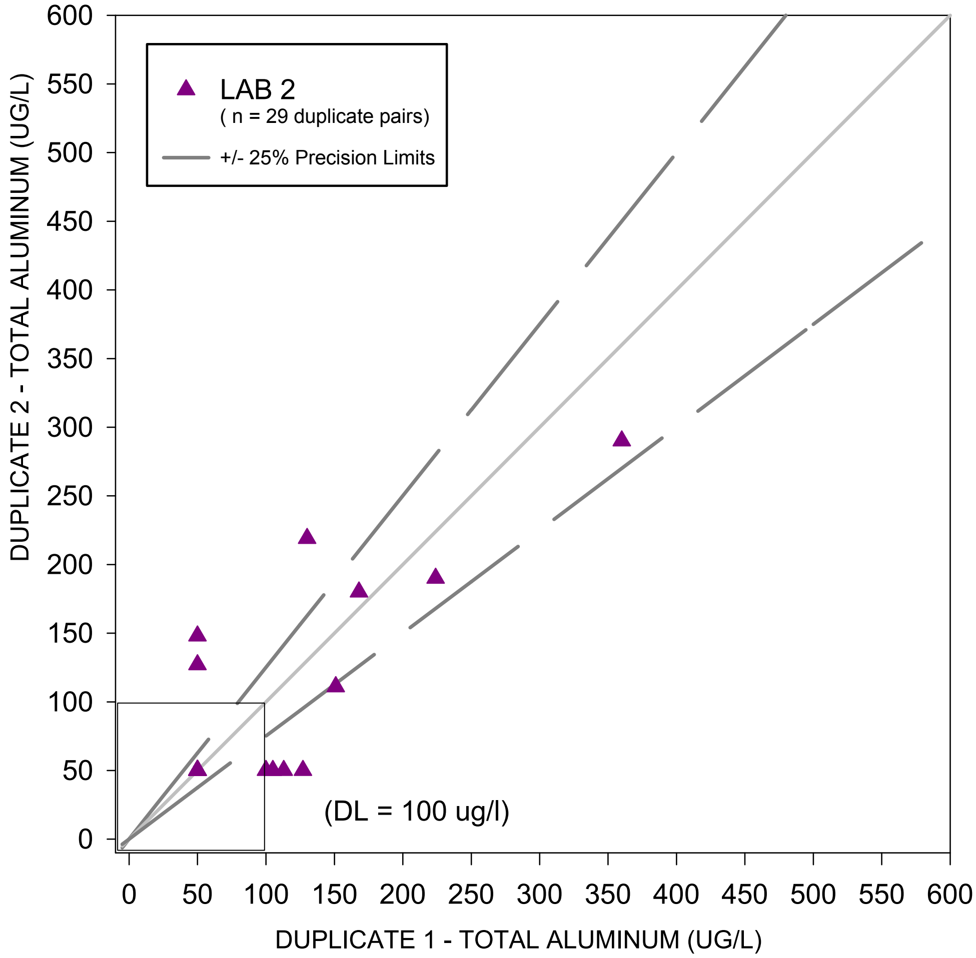
Figure Al-1 plots the concentration of aluminum for samples tested at the second laboratory. Most values are below 250 ug/L where there was less precision in duplicate sample results.

Figure Al-1. Total Aluminum Concentrations for All Site Categories vs. Date - Lab 2 Only



Duplicate sample results (29 pairs) are presented in Figure Al- 2. It is obvious from the Figure that the precision wavers a bit as the concentrations approach the detection limit. Forty-eight blank samples were tested and three were found to have detectable concentrations of aluminum. Two of those were near the detection limit. The high aluminum in one blank sample lead to having the data flagged as an estimate for that blank sample as well as the stream samples collected by that crew that day.

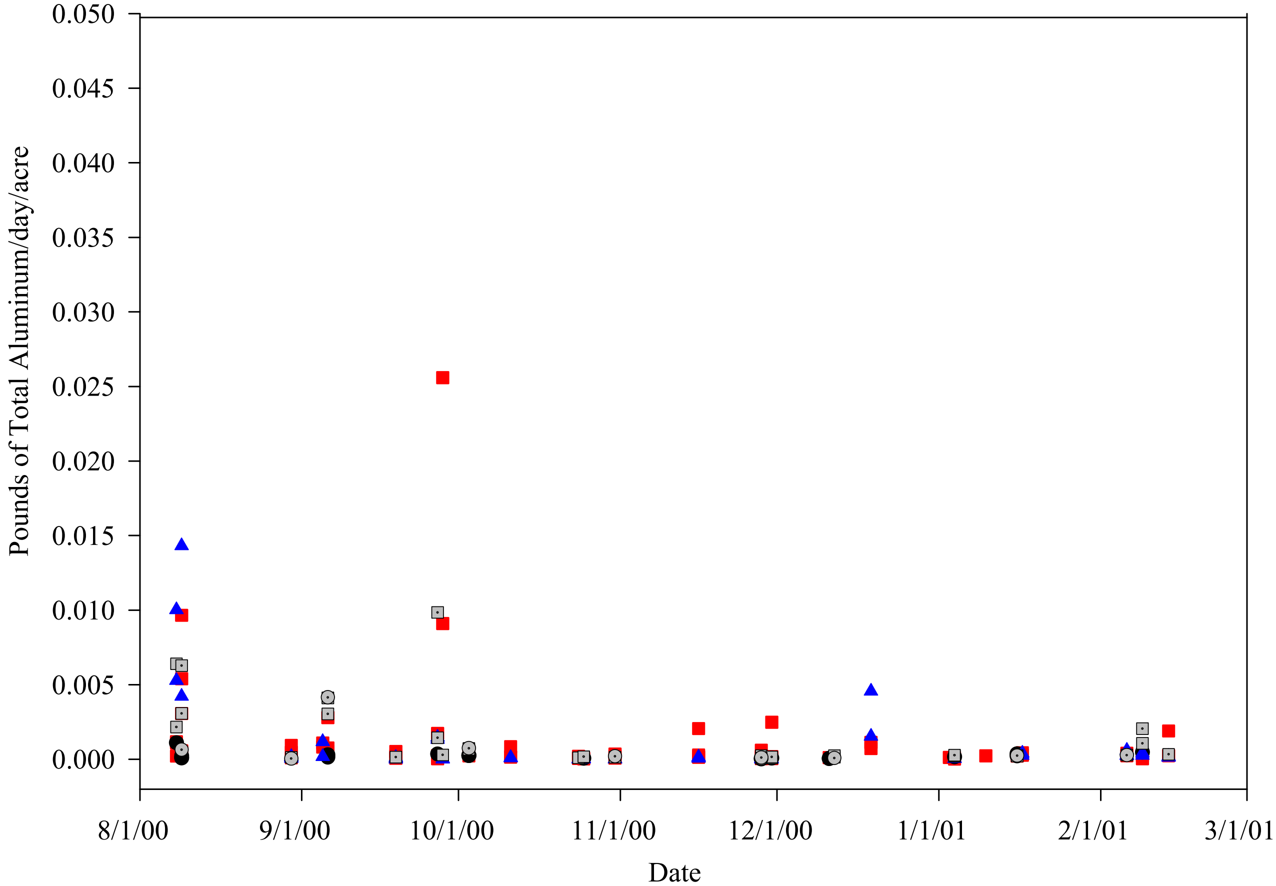
Figure Al-2. Comparison of Duplicate Samples - Total Aluminum - Lab 2 Only



6.1.b Aluminum Yield

The Yield values for total aluminum have been plotted vs date and are presented in Figure Al-3. Most yield rates are below 0.01 pounds per day per acre and there is no obvious pattern in the results. MTM/VF mining does not appear to produce a great difference in the Yield of aluminum within the study area.

Figure Al-3. Aluminum Yield for All Site Categories vs. Date - Lab 2 Only



6.1.c Dissolved Aluminum

Field crews filtered samples to check for dissolved aluminum. The second laboratory detected it in only five (2 %) of 213 samples with the maximum value being 129 ug/L. The values are listed below. Dissolved aluminum was detected in only one set of duplicate samples at the second laboratory at the detection limit of 100 ug/L. There is no clear indication that MTM/VF mining changes the concentration of dissolved aluminum in streams.

Site	Category	Dissolved Aluminum (ug/L)
MT-39	Unmined	121
MT-45	Mined	110
MT-69	Mined/Residences	100
MT-75	Filled/Residences	105
MT-79	Mined	129

6.2 Total Beryllium - Maximum 130 ug/L

The second laboratory analyzed 213 samples for beryllium in this study. The QA/QC review rejected none of those values resulting in 100 % completeness. Beryllium was not detected in any samples analyzed at the second laboratory. There was no detectable concentration of beryllium in any duplicate sample nor in any blank sample. There is no indication that MTM/VF mining changed the concentration of beryllium in streams in the study area.

6.3 Chloride - Maximum 230 mg/L

There were 213 samples analyzed for chloride by the second laboratory during this study. None were rejected in the QA/QC review resulting in 100 % completeness for the data set. The maximum concentration of chloride was 37.6 mg/L. The detection limit was 5 mg/L. None of the blank samples had detectable levels of chloride. There is no indication that MTM/VF mining caused any violation of WVDEP's stream water quality criterion for chloride during this study.

6.4 Dissolved Oxygen - Minimum 5.0 mg/L

Dissolved Oxygen is a field reading. There were 475 field readings for Dissolved Oxygen and 12 were rejected in the QA/QC review.The percent completeness in 97.47 %. Only 9 of the values were less than the minimum stream criterion of 5 mg/L, and they are listed below in Table DO-1. The minimum value recorded was 3.77 mg/L but all other values were in the 4 mg/L range. They were measured in June, August, or October. One was at an Unmined site, five were in Mined sites, and one each in Filled, Filled/Residence, and Mined/Residence.

TABLE DO-1
Samples Not Meeting Aquatic Life Minimum Criterion of 5.0 mg/L for Dissolved Oxygen

Station ID	EIS CLASS	SAMPLE DATE	VALUE (mg/L)
MT13	Unmined	10/26/99	3.77
MT79	Mined	06/13/00	4.09
MT79	Mined	08/09/00	4.12
MT78	Mined	08/09/00	4.25
MT81	Mined	06/13/00	4.37
MT81	Mined	08/09/00	4.38
MT75	Filled/Residences	06/13/00	4.47
MT69	Mined/Residences	06/13/00	4.66
MT64	Filled	06/13/00	4.88

WVDEP's stream criterion for Dissolved Oxygen was violated in only 2% of the samples in this study and those were in the seasons of summer and fall. There is no indication that MTM/VF mining caused violations of dissolved oxygen criteria in the study area.

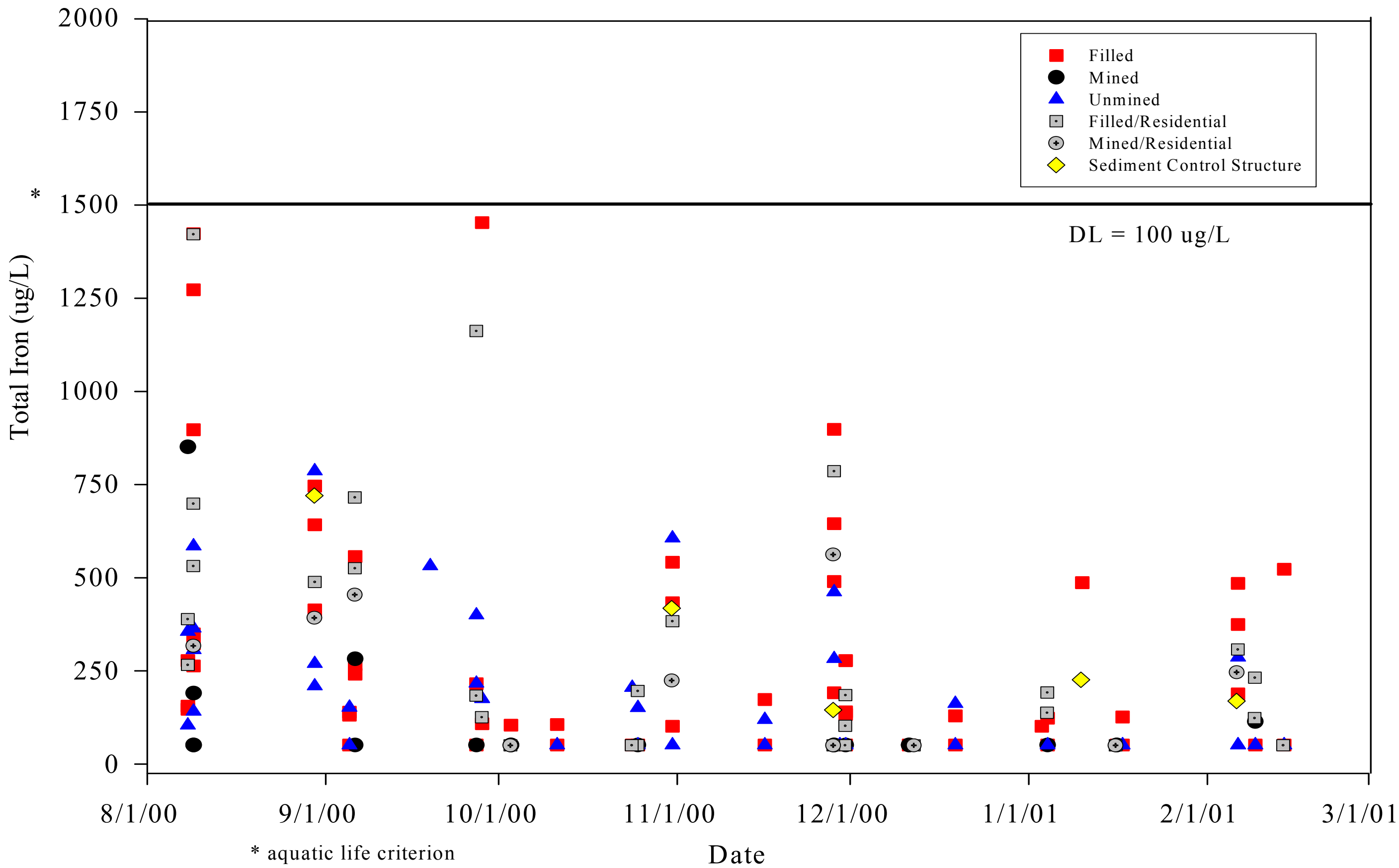
6.5 Total Iron - Maximum 1,500 ug/L

There were 213 samples analyzed for iron at the second laboratory and eight were rejected in the QA/QC review resulting in 96.24 % completeness. The detection limit was 100 ug/L.

6.5.a Iron Concentration in Stream Samples

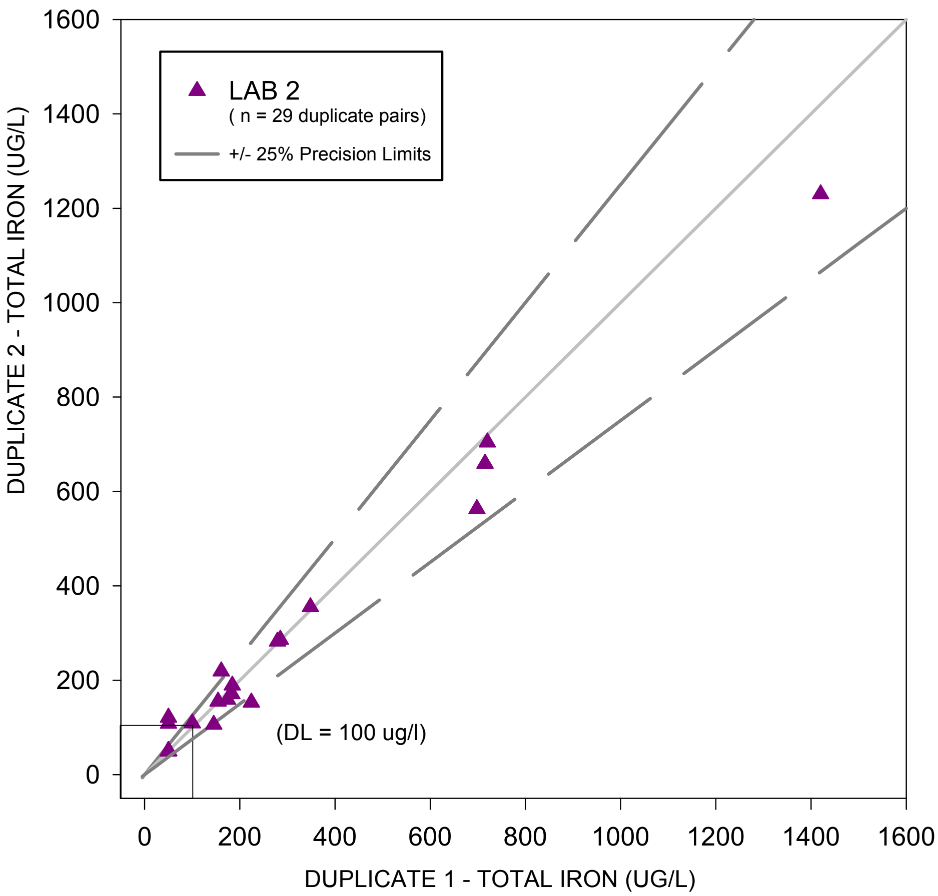
The iron concentration of each stream sample analyzed at the second laboratory during this study is presented in Figure Fe-1. The stream criterion of 1500 ug/L is indicated on the figure. There were no violations of the criterion for iron, but several samples from sites in the category Filled approached the limit during the fall of 2000. There is no clear indication that MTM/VF mining caused violations of the iron limit in streams in the study area.

Figure Fe-1. Total Iron Concentrations for All Sites vs. Date - Lab 2 Only



The results of duplicate samples are plotted in Figure Fe-2. The results are precise in the higher concentrations but waver as the concentration approached the detection limit. Only one of the 47 blank samples had a detectable concentration of iron.

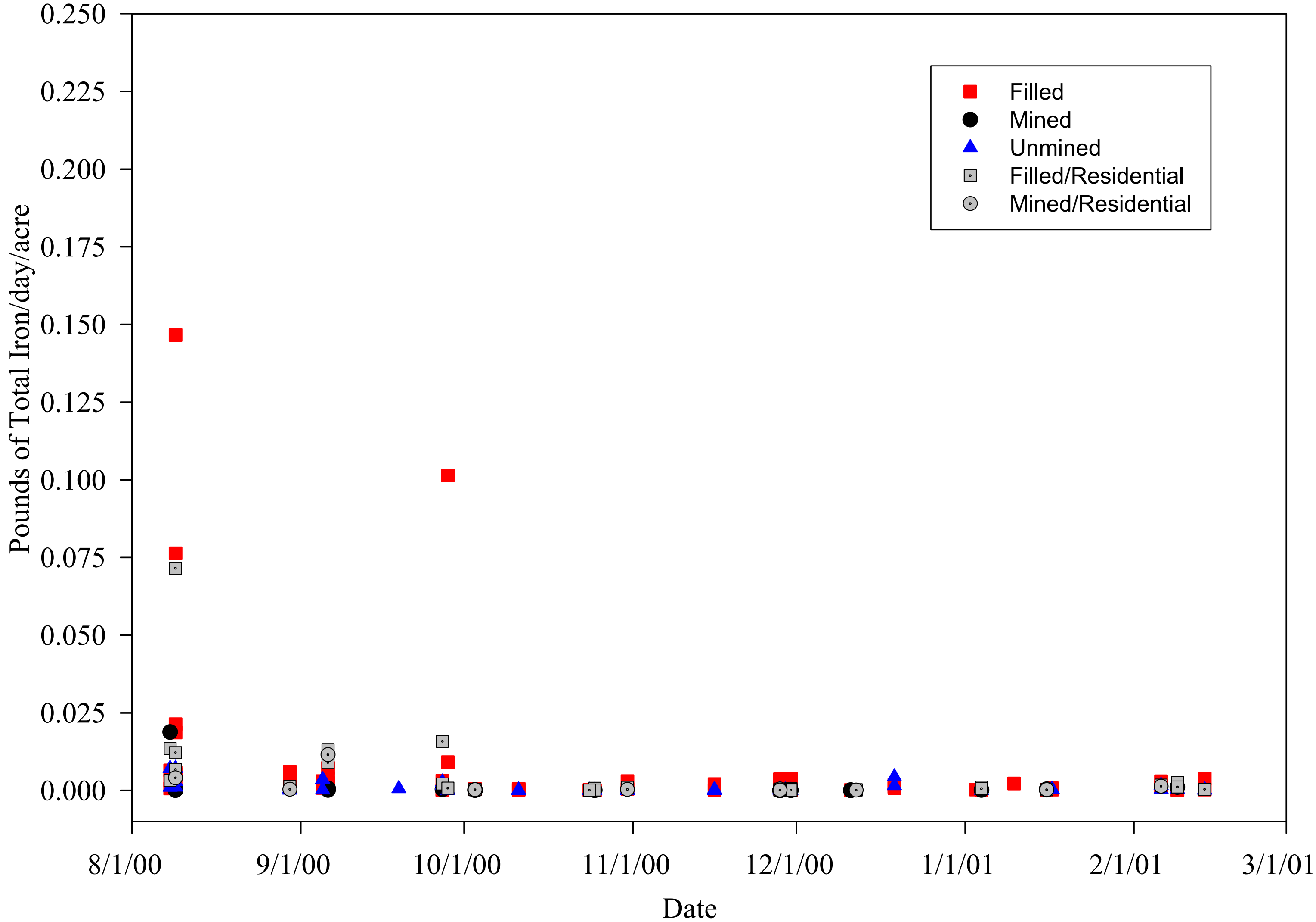
Figure Fe-2. Comparison of Duplicate Samples - Total Iron - Lab 2 Only



6.5.b Iron Yield

The Yield values for iron have been plotted vs date and are presented in Figure Fe-3. Although there are a couple higher values at Filled sites, most are values are below 0.01 pounds per day per acre. Variations in Yield rates for total iron could have several causes including changing amounts of suspended sediment that contains iron. The amount of suspended sediment in a stream is impacted by rainfall, ponds and vegetation cover on mine sites. The actual cause of the variation observed here is not known. There is no clear indication that MTM/VF mining changes Iron Yield in the study area.

Figure Fe-3. Iron Yield for All Sites vs. Date - Lab 2 Only



6.5.c Dissolved Iron

Dissolved iron was filtered in the field and 208 samples analyzed at the second laboratory passed the QA/QC review. A total of 33 samples (16 %) had values above the detection limit of 100 ug/L. Four of those samples came from two sites in the "Unmined" category while twenty-one of the samples came from nine sites in the "Filled" category. The "Filled" site MT-18 had dissolved iron on each sampling occasion ranging from a low of 200 ug/L to a high of 490 ug/L. The adjacent "Filled" site MT-14 had five detectable values from 110 ug/L to 483 ug/L. The other seven "Filled" sites had detectable concentrations of dissolved iron on only one or two occasions. Some "Filled" sites have persistent dissolved iron up to 480 ug/L and some "Unmined" sites have intermittent dissolved iron up to 390 ug/L.

6.6 Total Mercury - Maximum 2.4 ug/L

There were 213 samples analyzed for mercury at the second laboratory and 174 values passed the QA/QC review. The percent completeness is 81.69 %. None of the samples had a detectable concentration of mercury. The detection limit was 0.2 ug/L. No stream samples results exceeded the stream criterion of 2.4 ug/L. There is no indication that MTM/VF mining activities cause a measurable increase in the concentration of mercury in streams in the study area.

6.7 pH - Minimum 6.0, Maximum 9.0

There were pH measurements made in the field and the laboratory in this study, but only the field values are valid in evaluating compliance with stream limits. All 476 records of field pH in this study have been judged valid so the data set completeness is 100 %. Only three of those values fell outside of the limits of 6.0 to 9.0 set by the WVDEP. All three were for Unmined sites. This could be a result of acid deposition but that is not known for sure. The sites are:

Table pH - 1. Samples Not Meeting pH Criteria - 6.0 to 9.0

Station ID	EIS Category	Sample Date	Value
MT-03	Unmined	11/28/00	5.87
MT-13	Unmined	11/28/00	5.44
MT-50	Unmined	08/09/00	5.79

There were no violations of stream pH criteria resulting from MTM/VF mining identified during this study.

6.8 Total Selenium

There were 213 samples analyzed for selenium in the second laboratory for this study. The QA/QC review rejected three values resulting in 98.59 % completeness. The detection limit was 3 ug/L at the second laboratory.

Selenium is essential for life in very small amounts but is highly toxic in slightly greater amounts (Lemly 1996, page 427). In 1987, the EPA lowered the recommended stream water quality criterion for selenium to 5 ug/L to protect aquatic life. West Virginia has adopted that same limit as their stream criterion. Selenium is strongly bioaccumulated in aquatic habitats (Lemly 1996, page 435). "Waterborne concentrations in the low-ug/l range can bioaccumulate in the food-chain and result in an elevated dietary selenium intake and the reproductive failure of adult fish with little or no additional symptoms of selenium poisoning in the entire aquatic system. .... The most widespread human-caused sources of selenium mobilization and introduction into aquatic ecosystems in the U.S. today are the extraction and utilization of coal for generation of electric power and the irrigation of high-selenium soils for agricultural production" (Lemly 1996, page 437).

The West Virginia Geologic and Economic Survey has information on selenium posted on their website (http;//www.wvgs.wvnet.edu/www/datastat/te/SeHome.htm). It notes:

> Selenium occurs in coal primarily within host minerals, most within commonly occurring pyrite...... An unpublished study at WVGES using SEM found selenium ... in 12 of 24 coal samples studied, mainly in the upper Kanawha Formation coals. .... Selenium in West Virginia coals averaged 4.20 ppm...... Coals containing the highest selenium contents are in a region of south central WV where Allegheny and upper Kanawha coals containing the most selenium are mined.... Selenium is not an environmental problem in moist regions like the Eastern U.S. where concentrations average 0.2 ppm in normal soils.

Summarizing this information, we see that in the region MTM/VF mining, the coals can contain an average of 4 ppm of selenium, normal soils can average 0.2 ppm, and the allowable limits in the streams are 5 ug/L (0.005 ppm). Disturbing coal and soils during MTM/VF mining could be expected to result in violations of the stream limit for selenium.

6.8.a Selenium Concentration in Stream Samples

Laboratory results for selenium from the second laboratory are shown in Figure Se-1. There are 66 violations of the stream criterion. All values above the stream criterion of 5 ug/L are at Filled sites and many of those are several times greater than the detection limit of 3 ug/L. The elevated values of selenium appear to be closely related to MTM/VF mining activity.
There were 30 sets of duplicate samples for selenium tested in the second laboratory. One set of duplicate samples was rejected in the QA/QC review. Figure Se-2 plots the results of duplicate samples. The precision of results of the duplicate samples at the second laboratory indicate that data can be used to identify violations of the stream criterion for selenium.

Figure Se-1. Selenium Concentrations at All Sites vs. Date - Lab 2 Data Only

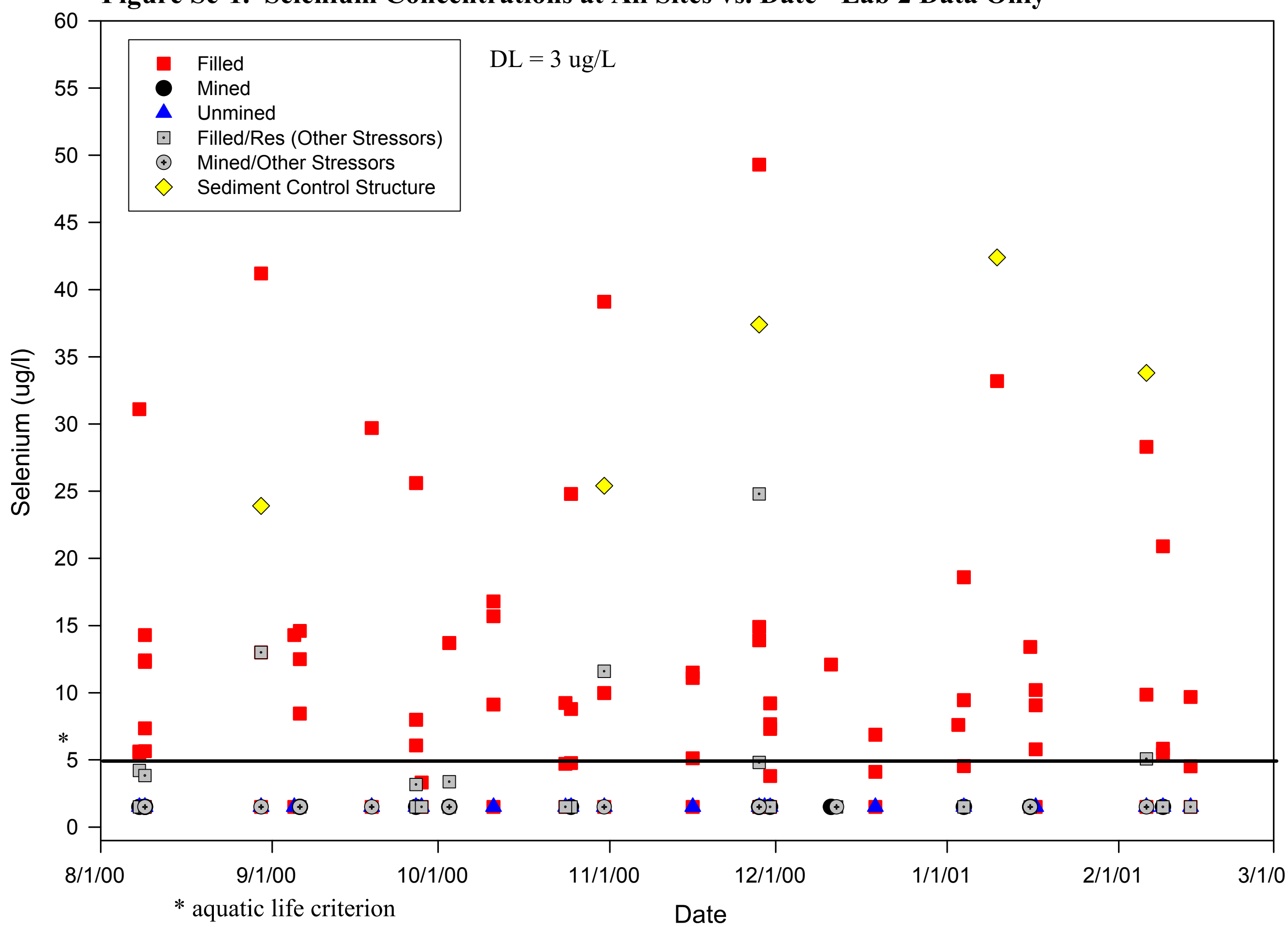
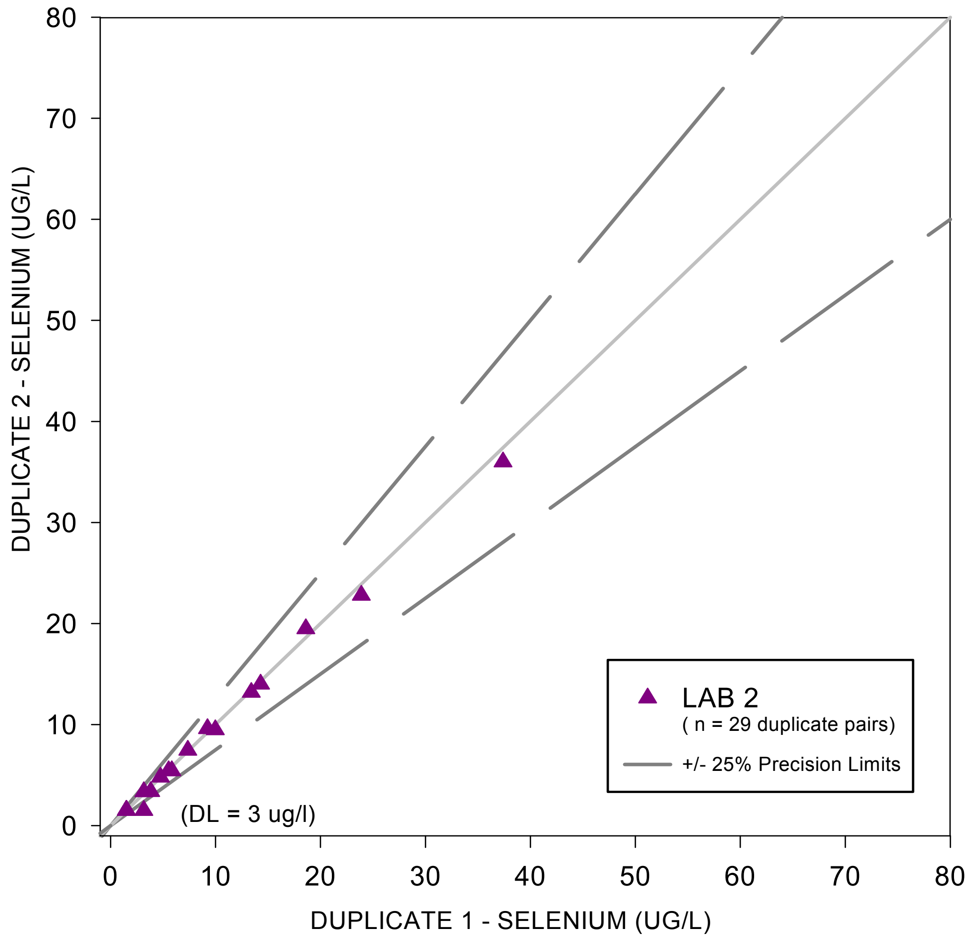


Figure Se-2. Comparison of Duplicate Samples Total Selenium - Lab 2 Only

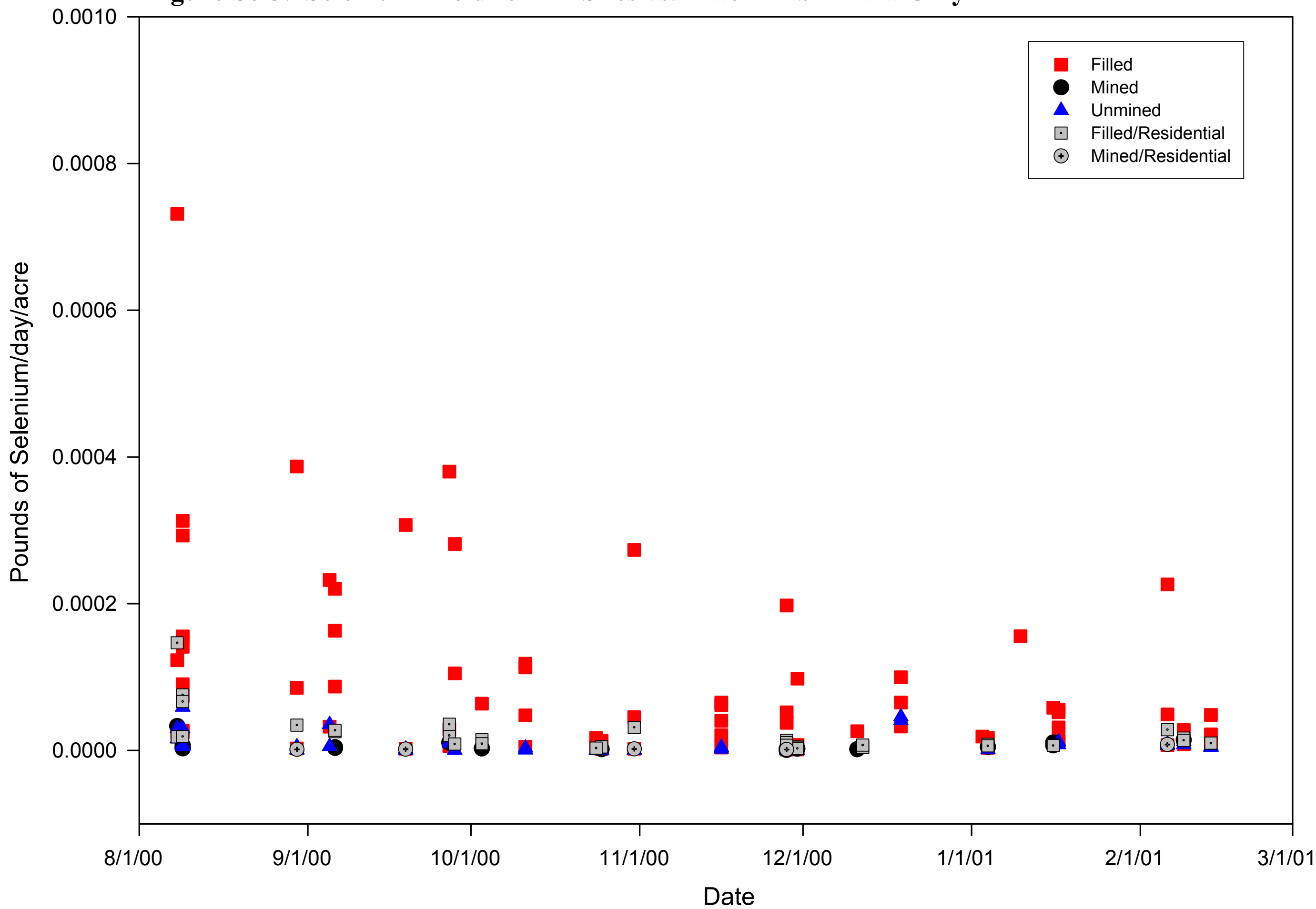


Accuracy was evaluated using spiked duplicates samples prepared in the laboratory and reviewed in the QA/QC review. Only one of the 50 blank samples tested in the second laboratory had a detectable concentration of selenium. The selenium dataset from the second laboratory is suitable for evaluating violations of the stream criterion of 5 ug/L.

6.8.b Selenium Yield

The Yield of selenium for all site samples is presented in Figure Se-3. The very low Yield rates for selenium are evident in the Figure. As noted earlier, even very small amounts of selenium in coals and soils can leach or erode to streams and exceed the water quality criterion. The Yield rates in sites exceeding the criterion were as low as 0.0002 pound per day per acre.

Figure Se-3. Selenium Yield for All Sites vs. Date - Lab 2 Data Only



6.8.c Distribution of Sites Violating the Stream Criterion - Lab 2 Only

It was noted earlier that **66 violations of the stream criterion for selenium were identified in samples tested at the second laboratory**. The period of sampling began in August 2000 and ran through February 2001. Each site was visited six times in this period and samples were collected at each site if there was flow in the stream. There were 13 sites with selenium concentrations above the criterion and all are in the Filled category. Sites MT- 18, 32, 34B, 64, 98, and 103 exceeded the criterion in all six samples. Sites MT- 15, 23, 24, 57B, and 104 exceeded the criterion in five of the six samples. Sites MT-25B and 52 exceeded the criterion in two of the six samples.

The **average selenium concentration** for each site in the study was calculated for the last six months of the study and plotted on maps to better evaluate the distribution of the sites with high selenium. Figures Se-4 through Se-9 are maps of the study area showing the locations of the sites and the mean concentration of selenium reported by the second laboratory. Many sites had no detectable (N.D.) concentration of selenium reported by the laboratory, but that does not necessarily mean they have zero selenium. The laboratory's detection limit (DL) for selenium was 3 ug/L. In **calculating statistics for a site**, all samples having a reported concentration of N.D. were arbitrarily assigned a value of one half the D.L. or 1.5 ug/L. If the mean selenium concentration for a site is 1.5 ug/L, then all the values were below the detection limit. This is indicated on the maps by "Below D.L."

Figure Se-4 is a map of the entire study area which plots the locations of sites with a high median value for selenium concentrations. All violations of the criterion were at Filled sites. The sites with high selenium are scattered across the entire region of mountaintop mining, but within each watershed they seem be clustered in only a portion of the study area. Maps for each watershed were prepared to show the location and average concentration of selenium at the monitoring sites.

Figure Se-4. Mean Selenium Concentrations for USEPA Stream Sampling Stations within the Region of Major Mountaintop Removal Mining Activity in West Virginia.

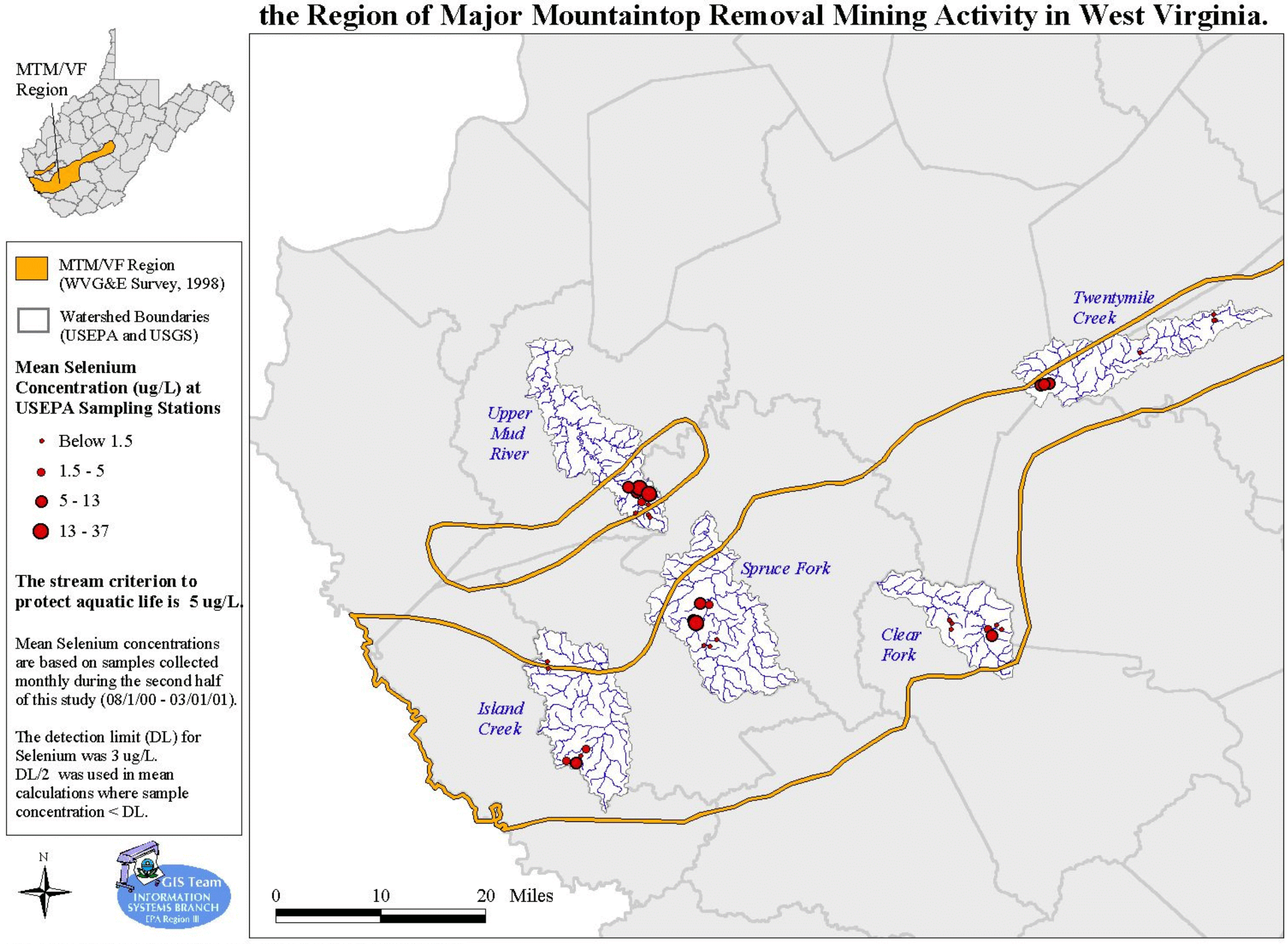


Figure Se-5. Mean Selenium Concentrations for USEPA Stream Sampling Stations within the Upper Mud River Watershed, West Virginia.

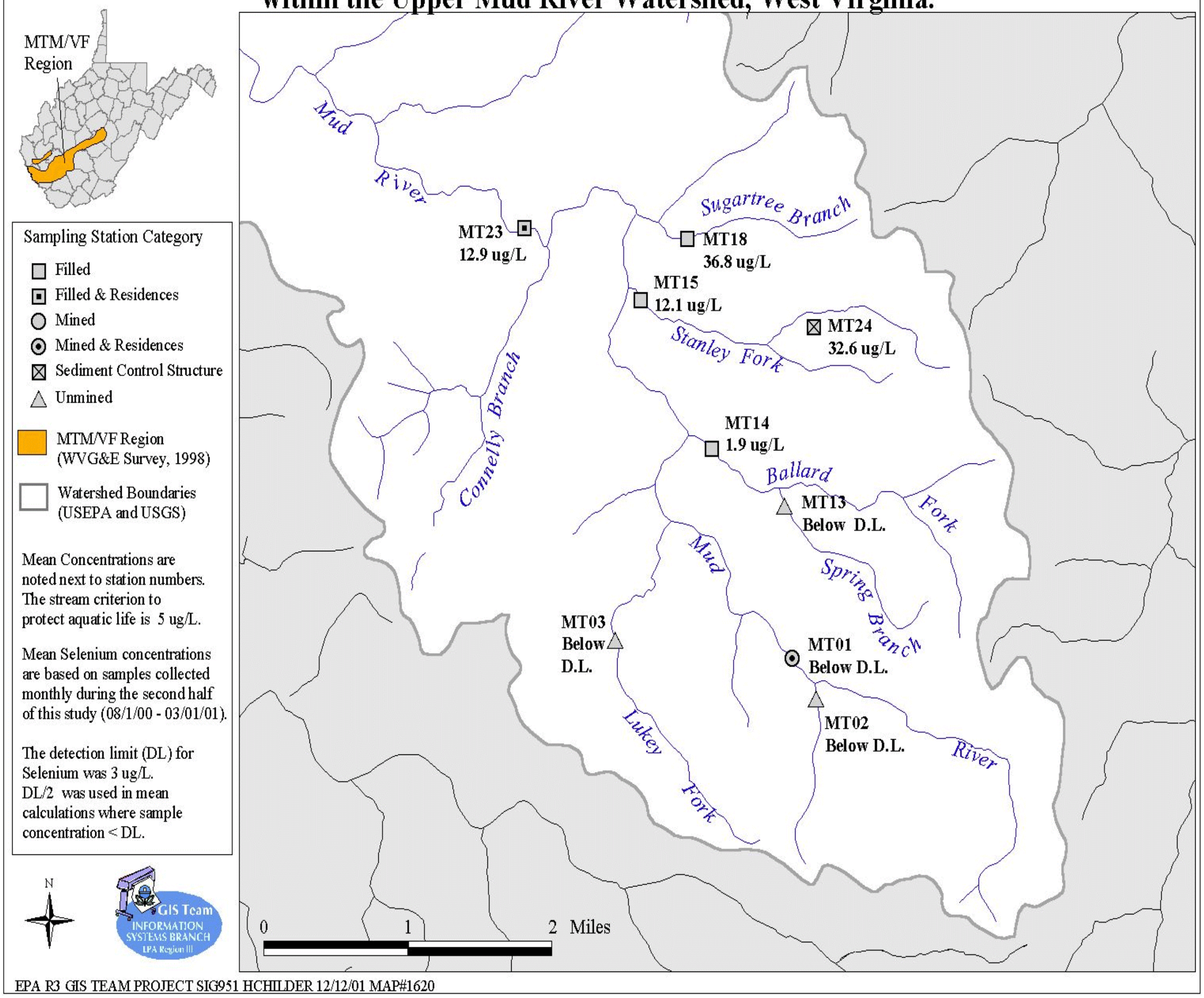


Figure Se-5 covers the Upper Mud River Watershed. Site MT-24 is actually in a diversion ditch on a reclaimed MTM/VF mine. Site information is:

Site ID	# of Fills /Year of Permit #	Average Selenium (ug/L)	Watershed (acres)
MT-14	8 / 1985, 88, 89	1.9	1,527
MT-15	6 / 1988, 89, 91, 92, 95	12.1	1,114
MT-18	2 / 1992, 95	36.8	479
MT-23	26 / 1985, 88, 89, 91, 92, 95, 96	12.9	10,618
MT-24	1 / 1988, 89	32.6	unknown

The level of selenium upstream other upstream sites MT-01, 02, 03, and 13 were all below the detection limit of 3 ug/L. There is a source of selenium in the upper portion of Sugartree Branch and Stanley Fork where there has been MTM/VF mining activity.

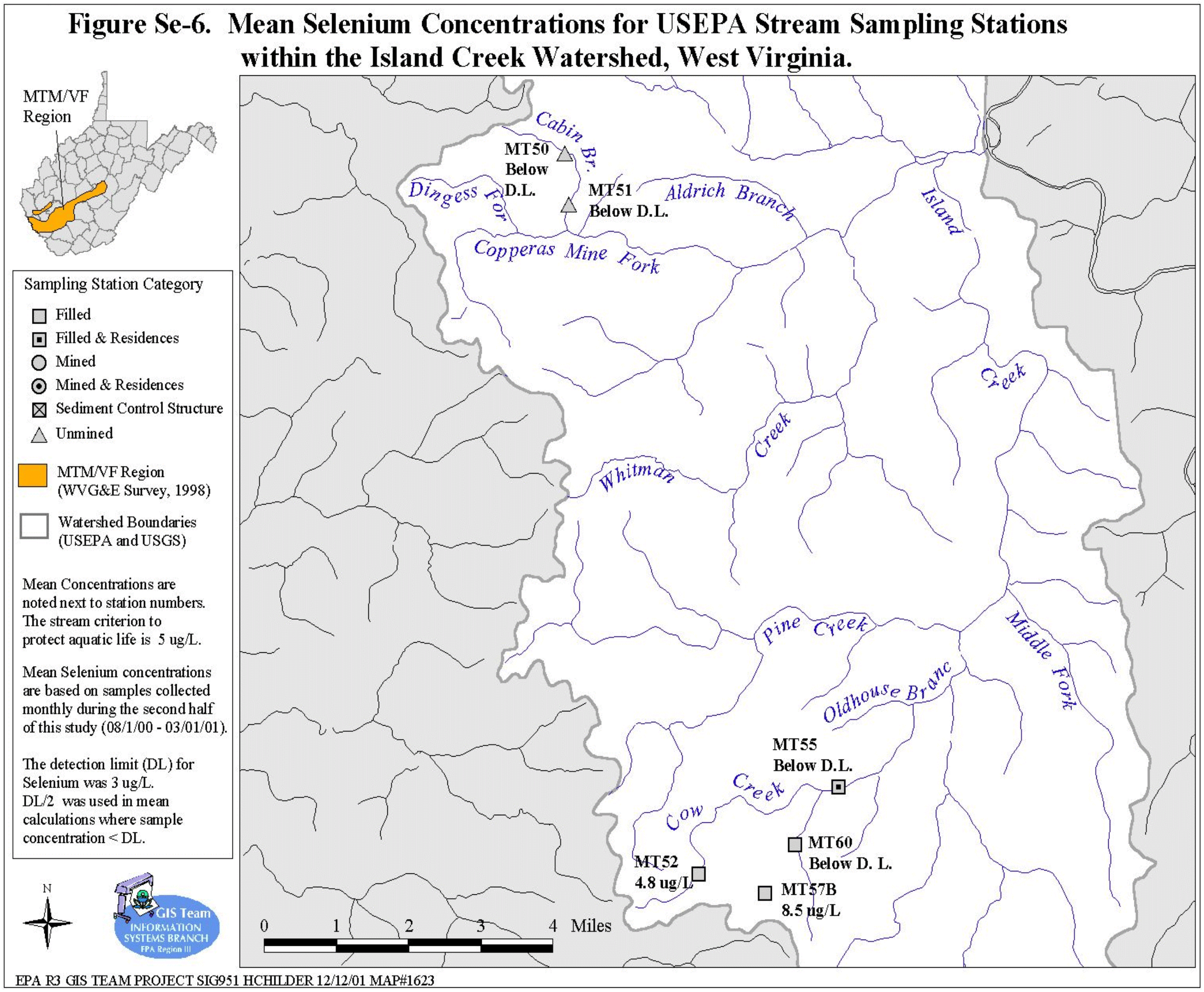


Figure Se-6 shows the average concentrations at the sites in the Island Creek watershed. In the Island Creek watershed there were two adjacent tributaries that exceeded the selenium criterion. The average value at MT-52 was 4.8 ug/L, and next door was MT-57B with an average of 8.5 ug/L. These values are near the detection limit of 3 ug/L. There was no detectable concentration of selenium downstream at MY-55 or MT-60. Dilution and the lack of additional sources of selenium could cause this. The other sites in this watershed (MT-50 & 51) had no detectable selenium. There appears to be a source of selenium in the upper portion of Cow Creek watershed where there has been MTM/VF mining activity.

Figure Se-7. Mean Selenium Concentrations for USEPA Stream Sampling Stations within the Spruce Fork Watershed, West Virginia.

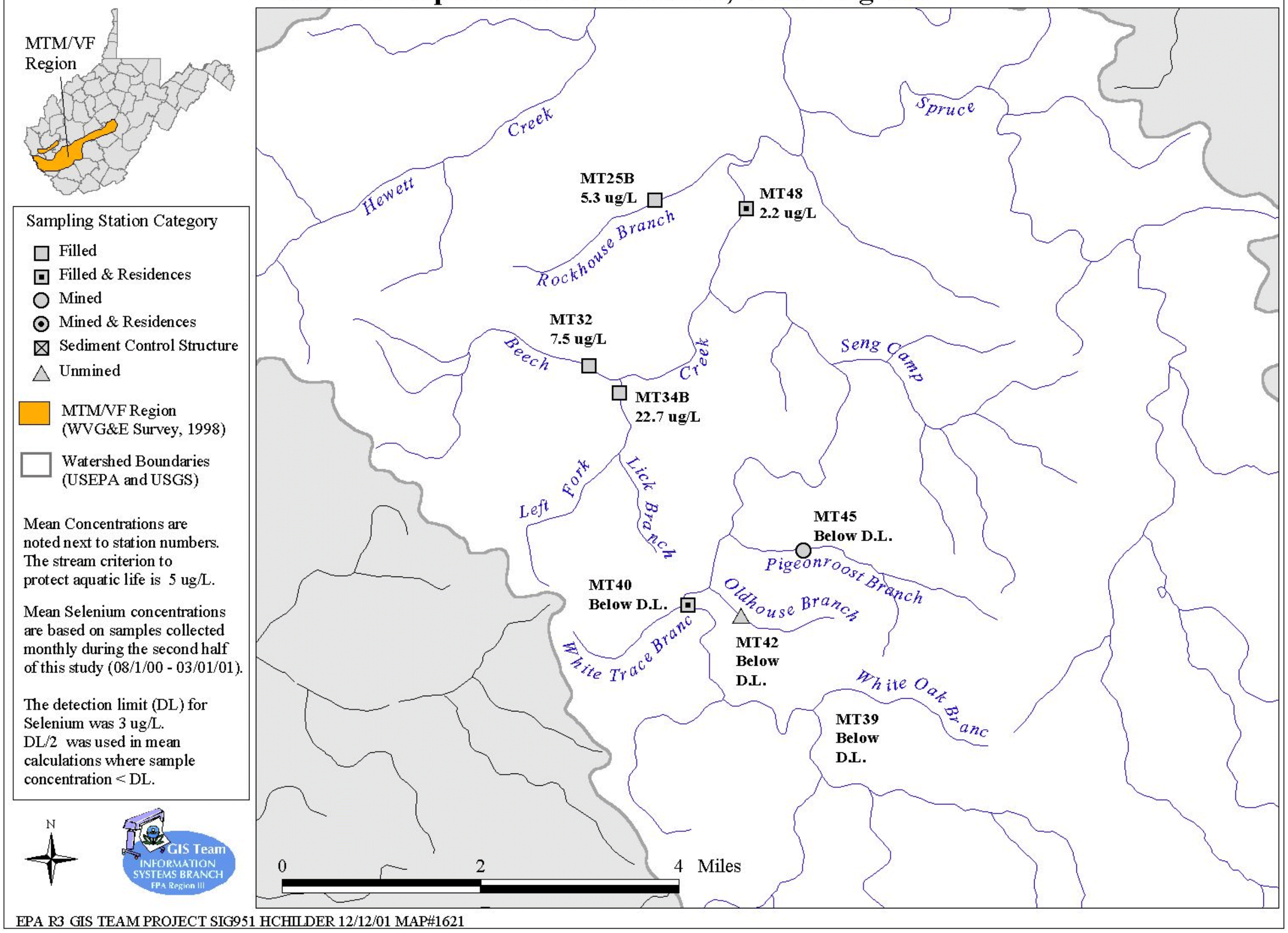


Figure Se-7 covers the sites within the Spruce Fork watershed. There were three sites on tributaries with fills in the Spruce Fork watershed that exceeded the criterion. Data on those sites is listed below:

Site ID	# of Fills /Year of Permit #	Average Selenium (ug/L)	Watershed (acres)
MT-25B	1 / 1986	5.3	997
MT-32	5 / 1986, 88, 89, 91	7.5	2,878
MT-34B	- / 1985, 86	22.7	1,677
MT-48	22 / many + 4 communities	2.2	27,742

There was no detectable concentration at the four other sites to the south in this watershed (MT-39, 40, 42, 45). There is a source of selenium in the upper portion of Beech Creek above MT-32 and MT-34B and in Rockhouse Branch above MT-25B where there has been MTM/VF mining activity.

Figure Se-8. Mean Selenium Concentrations for USEPA Stream Sampling Stations within the Clear Fork Watershed, West Virginia.

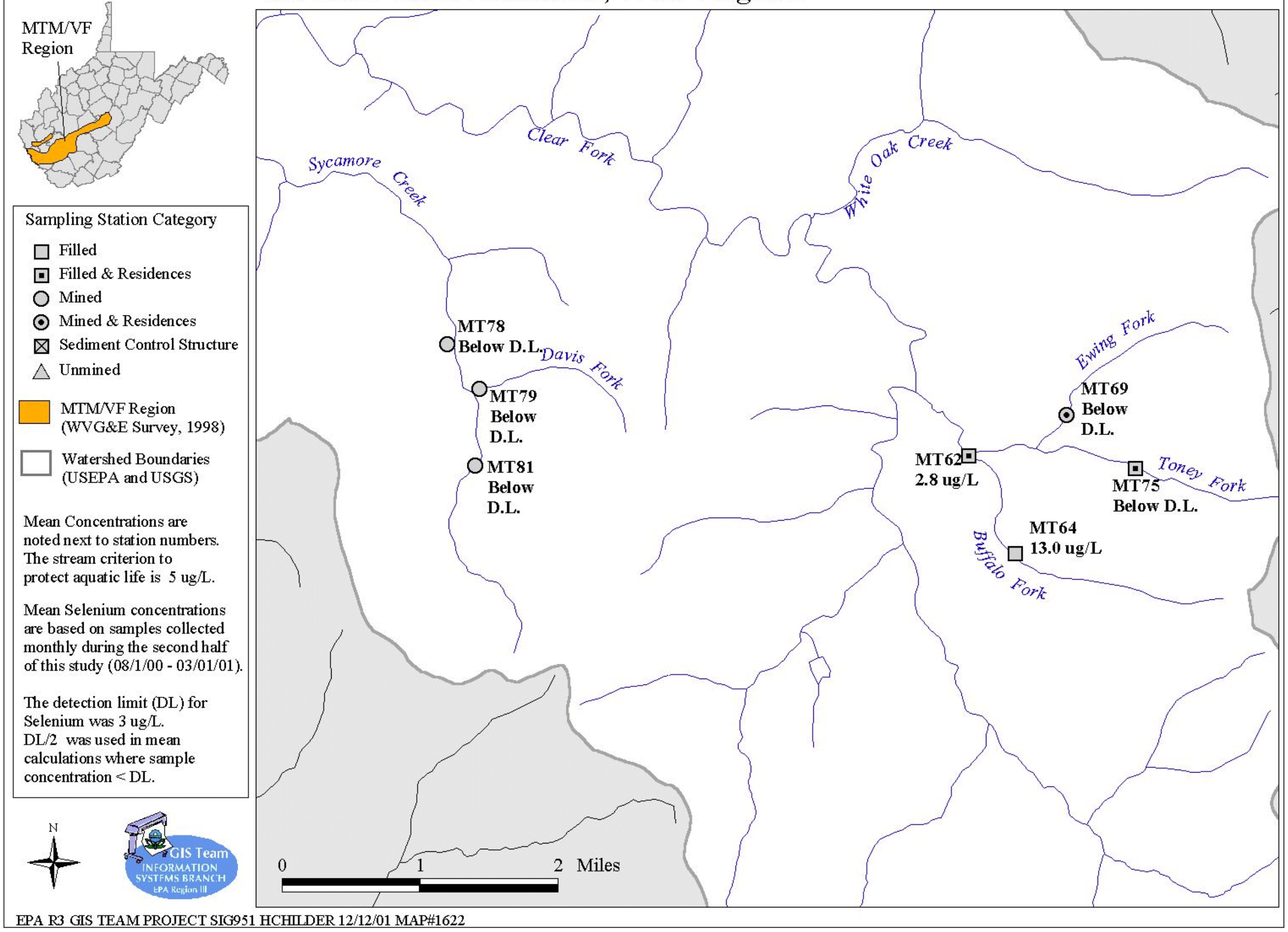


Figure Se-8 covers the sites within the Clear Fork watershed. Two sites in this watershed had measurable concentrations of selenium and data on them is listed below:

Site ID	# of Fills /Year of Permit #	Average Selenium (ug/L)	Watershed (acres)
MT-62	11 / 1989, 91, 92, 93	2.8	3,193
MT-64	5 / 1992, 93	13.0	758

The three other sites on Sycamore Creek (MT-78, 79, and 81) had no detectable concentration of selenium. There is a source of selenium in the upper portion of Buffalo Fork above MT-64 where there has been MTM/VF mining activity.

Figure Se-9. Mean Selenium Concentrations for USEPA Stream Sampling Stations within the Twentymile Creek Watershed, West Virginia.

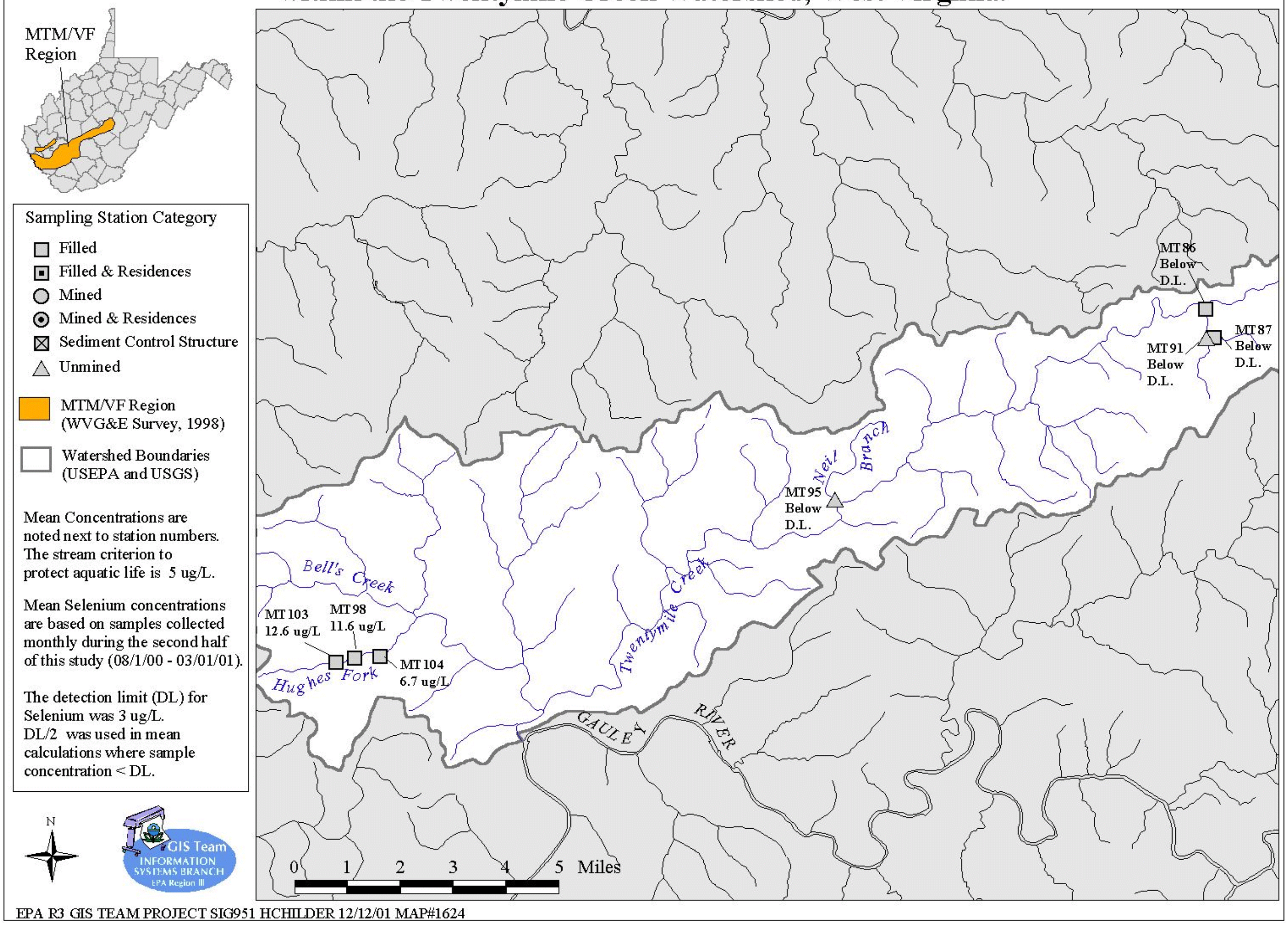


Figure Se-9 covers the sites within the Twentymile Creek watershed. The three sites in Twentymile Creek watershed that had excessive selenium are located along Hughes Fork and each one flows to the next. Data on the sites is listed below:

Site ID	# of Fills /Year of Permit #	Average Selenium (ug/L)	Watershed (acres)
MT-98	8 / 1977, 82, 90	11.6	1,208
MT-103	6 / 1977, 82, 90	12.6	1,027
MT-104	8 / 1977, 82, 90	6.7	2,455

The fact that the values get lower going downstream would indicate the effects of dilution and that there are no significant additional sources of selenium in this reach of stream. All other sites in the Twentymile watershed had no detectable concentrations of selenium. There is a source of selenium in the upper portion of Hughes Fork above MT-103 where there has been MTM/VF mining activity. It would be worthwhile to further evaluate what other common attributes, in addition to MTM/VF mining, exist among these sites. Those sites are: MT-18, MT-24, MT-25B, MT-32, MT-34B, MT-52, MT-57B, MT-64, MT-103.

6.9 Total Silver - Maximum Depends on Hardness

There were 213 samples analyzed for silver at the second laboratory. None were rejected in the QA/QC review so the percent completeness is 100 %. The detection limit was 10 ug/L. The second laboratory found no detectable concentration of silver in any duplicates or blanks or stream samples. MTM/VF mining does not appear to cause increased concentrations of silver to be released to streams in the study area.

6.10 Temperature - Maximum 87ºF May through November or 73ºF December through April

Temperature is a field measurement. There were 474 field measurements of stream temperature in this study. None of them exceeded the maximum allowable temperatures for West Virginia streams. Continuous temperature records, especially during the hotter summer months, would have been a better indicator of temperature.

7. OTHER EVALUATIONS

7.1 Parameters with Concentrations Below Detection Limits

In addition to total beryllium, total silver, and total mercury, there were eight other parameters which were not detected in any of the samples in this study reported in data from the second laboratory.

7.1.a Hot Acidity

The second laboratory tested for hot acidity in a few samples at the start of their contract work. The Study Plan called for only acidity, not hot acidity. Acidity was analyzed for all samples in this study and that data is discussed earlier in this report. There were 22 samples analyzed for hot acidity and none was detected in any sample. This limited amount of data on hot acidity does not support any conclusions.

7.1.b Total Antimony, Arsenic, Cadmium, Chromium, Cobalt, Thallium and Vanadium

There were 213 samples analyzed for these metals and none was detected in any sample at the detection limit of 5 ug/L. None of the blanks had detectable concentrations and all of the data passed the QA/QC review. MTM/VF mining did not impact the concentration of these metals in streams in the study area.

7.2 Flow Rate Data

The flow rate was measured 466 times when the stream was sampled in this study. There is a flow rate to go with 97.3% of the samples. Most flow rates were measured using standard stream gaging procedures and calculations. There has been considerable discussion and speculation regarding the impacts of MTM/VF mining on stream flows.

MTM/VF mining can affect runoff. Rain falling on a watershed either runs off in the stream or infiltrates into the ground. If it infiltrates, it either percolates through the rocks and eventually comes out of a spring that feeds a surface stream, or it is taken up by plants and stored or evaporated back into the atmosphere. Many aspects of MTM/VF mining activities can affect stream flow including: removing the trees and other plants; fracturing rocks; moving soil and rocks; constructing flow diversion channels and sedimentation ponds; constructing haul roads; reshaping and compacting mine spoil; constructing valley fills; and reestablishing vegetation on the mined area. MTM/VF activities can increase the base flows of streams while decreasing the peak flows of floods by temporarily storing the rainfall in ponds or in the increased voids in the spoil of mined areas. The Kentucky Geological Survey report *Hydrogeology, Hydrogeochemistry, and Spoil Settlement at a Large Mine-Spoil Area in Eastern Kentucky: Star Fire Tract* notes:

> Field investigations have identified numerous ground-water recharge and discharge zones at the mine spoil area. Recharge occurs by way of disappearing streams, ground-water infiltration along exposed boulder zones, and at areas where spoil is in contact with bedrock highwalls. Minor recharge occurs locally on the spoil's surface through macropores (snakeholes). Discharge of ground-water from the spoil occurs mainly through springs and seeps at the outslope of the spoil body. Ground-water movement within the spoil is controlled by the ground-water gradients within the spoil, which are a function of the buried topography and interaction of the recharge and discharge zones of low-permeability spoil. The spoil interior, lacking any major direct recharge from the surface, slowly accumulates water, whereas in the valley fills ground water moves at a rapid rate. Recharge to the valley fills comes from streams, adjacent bedrock aquifers, and from surface water that seeps in near the bedrock-spoil interface. (Wunsch 1996, page 25)

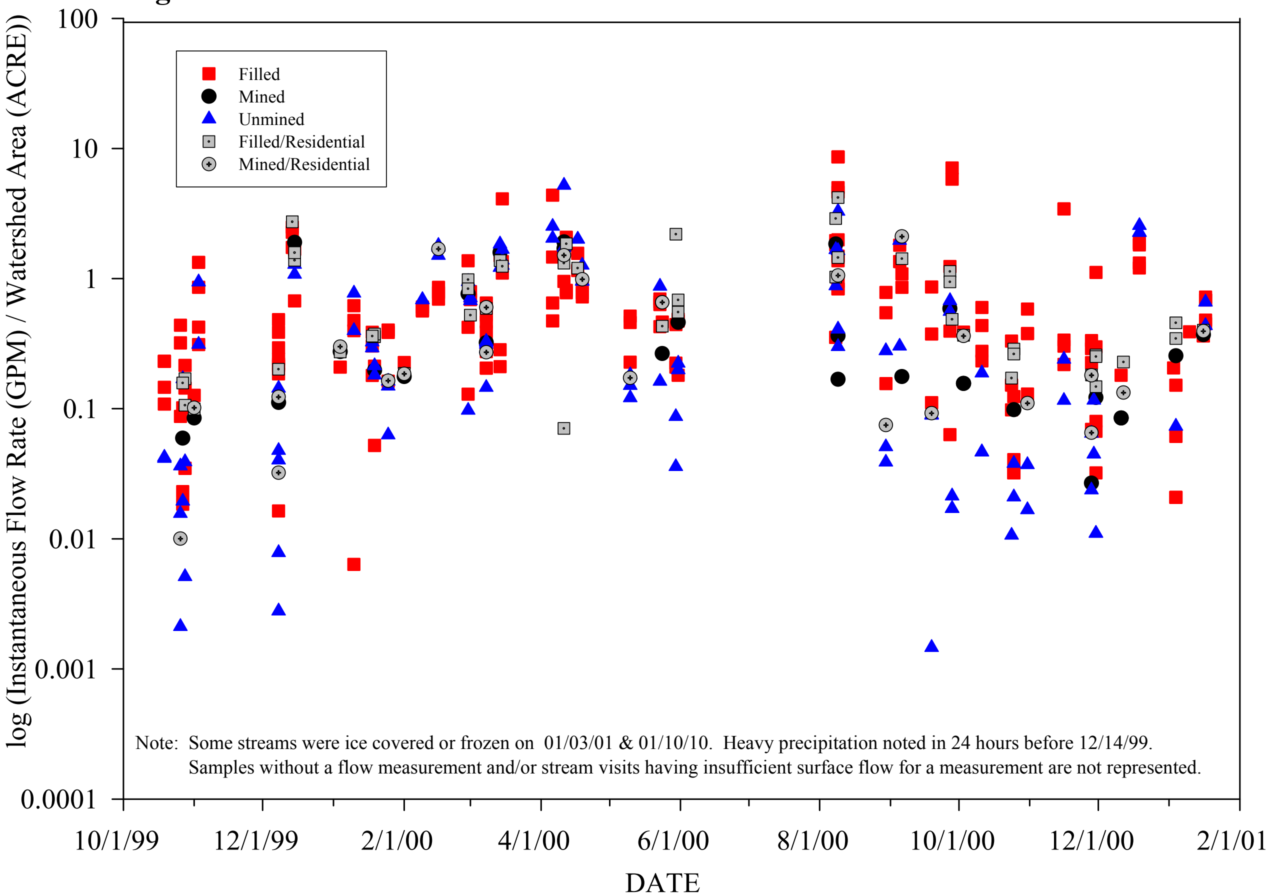
The impact of fills on base flow in streams has been investigated by several researchers. The USGS Water- Resources Investigations Report 01-4092, *Reconnaissance of Stream Geomorphology, Low Streamflow, and Mountaintop Coal-Mining Region, Southern West Virginia, 1999-2000* notes:

> ... the valley-fill sites can have about a 6-7 times greater 90-percent flow duration than unmined sites. (Wiley et al 2001, page 13)

The 90-percent flow duration is the flow that is exceeded 90 % of the time. The report indicates

that base flows of streams with valley fills are 6 to 7 times greater than the base flows of unmined areas.   Stream water quality below MTM/VF mines is also altered in base flow periods when the mineralized ground-water from the mined area becomes the major portion of the stream flow.
Figure Flow-1 plots the log of the normalized flow rate (the instantaneous flow divided by the

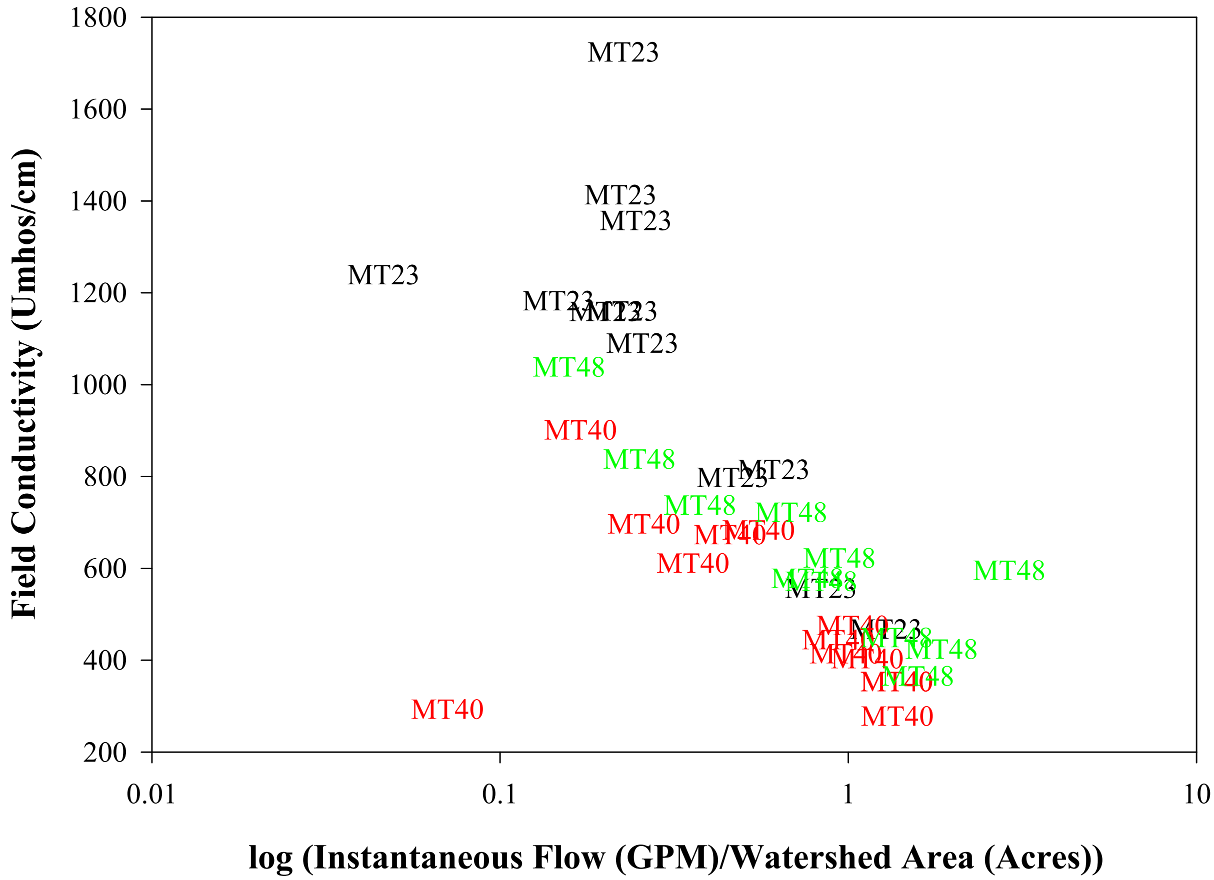
Figure Flow-1. Normalized Flow Rate vs. Date



watershed area) in gallons per minute per acre versus the date. It is noted that the lowest flows are often at Unmined sites. There is a broad range of normalized flow rates for this study area and some variation with the seasons is also evident. There does not appear to be any period of extremely low flow.

Cumulative impacts of MTM/VF mining are difficult to measure but the cumulative impacts on flow rate should be measurable. When the base flows of streams are increased by MTM/VF mining, the base flows of larger streams are also increased. Since the base flows from MTM/VF sites are higher in dissolved minerals, the conductivity of larger streams should increase as low flows occur. Figure Flow-2 plots the conductivity of samples for the three largest watersheds in this study (MT-23 the Mud River near Mud, MT-40 Spruce Fork near Blair, and MT-48 Spruce Fork near Dobra) vs the log of the normalized flow. The pattern of lower flows being associated

Figure Flow-2. Field Conductivity vs. Log (Instantaneous Flow / Watershed Area)



with higher conductivity is evident.

The flow rate data for each sampling event is part of the electronic data base of this report. While outside the scope of this report, there would be value in having experts evaluate the flow rate data comparing it with references and nearby long term stream flow records to identify impacts attributable to mining.

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ATTACHMENT 1

CHEMICAL PARAMETERS IN WEST VIRGINIA WATER QUALITY CRITERIA

Chemical Parameters Selected From West Virginia Water Quality Criteria

The chemical parameter, the water quality limit, and the type of limit are listed in italics. Any comments on the monitoring of each parameter are included in plain type.

Aluminum
Not to exceed 750 ug/L
Acute limits for cold and warm water streams
Total aluminum and dissolved aluminum were monitored in this study.

Ammonia
Limit determined using the tables and formulae in the national Criteria section of USEPA's Ambient Water Quality Criteria for Ammonia 1984 (EPA 440/5-85-001)
Acute and chronic limits for cold and warm water streams
Ammonia is not thought to be a normal contaminant from coal mining activities and was not monitored in this study.

Dissolved Trivalent Arsenic
Not to exceed 360 ug/L (Acute) nor 190 ug/L (Chronic)
Acute and chronic limits for cold and warm water streams.
Arsenic in trivalent form is not thought to be a normal contaminant from coal mining activities. This study monitored for total arsenic concentrations which would include the dissolved trivalent form. This study's grab sample results can be compared to the limit for dissolved trivalent arsenic to indicate the need for expanded monitoring in the future. If the total arsenic values are less than the limit for dissolved trivalent arsenic, no further studies are recommended. If however the total arsenic values are greater than the limit for dissolved trivalent arsenic, then further study might be recommended.

Beryllium
Not to exceed 130 ug/L
Acute limit for cold and warm water streams
Beryllium was monitored during this study.

Dissolved Cadmium
The one-hour average concentration shall not exceed the value determined by the following equation:

$$\text{Cd (ug/L)} = e^{[\{1.128\} \times \{\ln \text{hardness}\} - 3.828]} \times [1.101672 - \{(\ln \text{hardness}) \times (0.041838)\}]$$

Chronic limit for warm and cold water streams (acute limit is higher) -
Only total cadmium concentrations were monitored in the grab samples from the streams. This study's grab sample results can be compared to the one-hour average dissolved cadmium limit to indicate the need for expanded monitoring in the future.

<u>Chloride</u>
Not to exceed 860 mg/L (Acute) nor 230 mg/L (Chronic)
Warm and cold water streams
The 230 mg/L limit was used for this study.

<u>Dissolved Copper</u>
The one-hour average concentration shall not exceed the value determined by the following equation:

$$Cu\ (ug/L) = e^{[0.9422\ \{\ln hardness\}\ -\ 1.464]} \times 0.960$$

Acute limit for warm and cold water streams.
Only total copper concentrations were monitored in the grab samples from the streams. This study's grab sample results can be compared to the one-hour average dissolved copper limit to evaluate the need for expanded monitoring in the future.

<u>Cyanide</u> (as Free Cyanide HCN = CN^{-})
Not to exceed 22ug/L (Acute) nor 5 ug/L(Chronic)
Limits for both warm and cold water streams.
Cyanide is not thought to be a normal contaminant from coal mining activities and was not monitored in this study.

<u>Dissolved Oxygen</u>
Not less than 5 mg/L at any time
Limit for warm water stream.
Field crews monitored for dissolved oxygen during this study.

<u>Dissolved Hexavalent Chromium</u>
Not to exceed 15.3 ug/L(Acute) nor 6.93 ug/L (Chronic)
There are different limits for warm or cold water streams.
Dissolved hexavalent chromium is not thought to be a normal contaminant from coal mining activities. Total chromium was monitored in this study. Total chromium results can be compared to these limits for dissolved hexavalent chromium to evaluate the need for expanded monitoring in the future.

<u>Iron</u>
Not to exceed 1.5 mg/L
Chronic limit for warm and cold water streams.
Total iron was monitored in this study as well as dissolved iron.

<u>Dissolved Lead</u>
The one-hour average concentration shall not exceed the value determined by the following equation:

$$Pb\ (ug/L) = e^{[1.273\{\ln hardness\}\ -\ 1.46]} \times [1.46203 - \{(\ln hardness)(0.145712)\}]$$

Acute limit for warm and cold water streams

Only total lead concentrations were monitored in this study. This study's grab sample results can be compared to the one-hour average dissolved lead limit to evaluate the need for expanded monitoring in the future.

<u>*Total Mercury*</u>
Not to exceed 2.4 ug/L
Acute limit for warm and cold water streams
Total mercury was monitored in this study.

<u>*Methylmercury*</u> *(water column)*
Not to exceed 0.012 ug/L
Chronic limit for warm and cold water streams
Only Total Mercury concentrations were monitored in this study .

<u>*Dissolved Nickel*</u>
The one-hour average concentration shall not exceed the value determined by the following equation:

$$Ni = e^{[0.846 \{\ln hardness\} + 3.361]} \times [0.997]$$

Chronic limit for both warm and cold water streams
Only total nickel concentrations were monitored in this study. This study's grab sample results can be compared to the one-hour average dissolved nickel limit to evaluate the need for expanded monitoring in the future.

<u>*Nitrite*</u> *(as Nitrite-N)*
Not to exceed 1.0 mg/L (warm water stream) nor 0.60 mg/L (cold water stream)
The extremely short holding time for Nitrite analyses forced us to monitor for Nitrate + Nitrite. The Nitrite limit can be compared to the values for Nitrate + Nitrite only for an indication of which sites may possibly have Nitrite contamination.

<u>*Organics*</u>
Limits for chronic exposure in warm and cold water streams are -

Chlordane -	*4.3 ng/L*
DDT -	*1.0 ng/L*
Dieldrin -	*1.9 ng/L*
Endrin -	*2.3 ng/L*
Toxaphene -	*0.2 ng/L*
PCB -	*14.0 ng/L*
Methoxychlor-	*0.03 ug/L*

None of these Organics are thought to be a normal contaminant from coal mining activities. They were not included in the list of parameters to be monitored.

<u>*pH*</u>
No values below 6.0 nor above 9.0 (higher values tolerated if due to photosynthetic activity).

Limits for acute and chronic warm and cold water streams
Field crews monitored for pH during this study.

<u>Phenol</u>
Not to exceed 10,200 ug/L (acute) nor 2,560 ug/L (chronic)
Limits for warm and cold water streams
Phenol is not thought to be a normal contaminant of concern from coal mining activities and was not monitored in this study.

<u>Radioactivity</u>
Gross Beta activity not to exceed 1000 picocuries per liter, etc......
Limits for both warm and cold water streams
Radioactivity is not thought to be a normal contaminant of concern from coal mining activities and was not monitored in this study.

<u>Selenium</u>
Not to exceed 20 ug/L (acute) nor 5 ug/L (chronic)
Limits for warm and cold water streams
The 5 ug/L limit was used for this study.

<u>Silver</u>
The limit varies from 1 ug/L to 43 ug/L depending on the hardness which varies from 0 mg/L to 600 mg/L and whether it is a cold water or warm water stream.
Chronic limits for warm and cold water streams.
Total silver was monitored in this study.

<u>Dissolved Silver</u>
The one-hour average concentration shall not exceed the value determined by the following equation:

$$Ag = e^{[1.72\{\ln \text{hardness}\} - 6.52]} \times 0.85$$

Acute limit for warm and cold water streams -
Only total silver concentrations were monitored in this study.

<u>Temperature</u>
..... not to exceed 87^O Fahrenheit during May through November nor 73^O Fahrenheit during December through April etc......
Acute limits for warm water streams
Field crews monitored for temperature in this study.

<u>Threshold Odor</u>
Not to exceed a threshold odor number of 8 at 104^O Fahrenheit as a daily average

Chronic limit for warm and cold water streams
Threshold Odor is not thought to be a normal contaminant from coal mining and was not monitored in this study.

<u>*Total Residual Chlorine*</u>
Not to exceed 19 mg/L (acute) nor11 ug/L
Warm water stream limits only - No chlorinated discharge allowed in cold water streams (chronic). Total Residual Chlorine is normally a parameter of concern only at sewage treatment facilities, water treatment plants, chemical plants or swimming pool discharges. It was not monitored in this study.

<u>*Turbidity*</u>
No discharge shall contribute to a net load of suspended matter such that the turbidity exceeds 10 NTU's over background turbidity when the background is 50 NTU or less, or have more than a 10% increase in turbidity (plus 10 NTU minimum) when the background turbidity is more than 50 NTUs
Chronic limit for warm and cold water streams -
Some of the field meters used in this study had the capability to monitor turbidity. The intermittent readings taken by some of the crews are not included in the results of the study. The limits also require upstream and downstream monitoring which was not part of the study plan.

<u>*Dissolved Zinc*</u>
The one-hour average concentration shall not exceed the value determined by the following equation:

$$Zn = [e^{\{(0.8743) \times (\ln \text{hardness}) + 0.8604\}}] \times [0.978]$$

Acute limit for warm and cold water streams (chronic limit is higher)-
Only total zinc concentrations were monitored in this study. This study's grab sample results can be compared to the one-hour average dissolved zinc limit to evaluate the need for expanded monitoring in the future.

ATTACHMENT 2

FIELD SHEETS FOR WATER SAMPLING AND FLOW MEASUREMENT

FIELD SHEET - WATER SAMPLING

STATION NUMBER ____________LOCATION____________________________________
DATE mm/dd/yy ____/_____/______TIME (military) ____________________ hours
INVESTIGATOR____
AGENCY ____

FIELD READINGS: Meter Make & ID:
pH __.___ Temperature _____ (C) Dissolved Oxygen (mg/L) ___.___
Conductivity (umhos/cm) _____
Calibration Data: Time:____ Initials:_____
pH Calibration (4.0)_____ (7.0)____ (10.0) ________ (Enter pH readings)
Conductivity Calibration (Conc. of Std. KCl _______), Reading: ________ umhos/cm
DO Calibration (Temp.)_______ (Air Calibration), Reading: _____ [Meters are Auto Altitude]
NIST Thermometer: Reference Temperature (0^0C - Ice/Water in ice chest) Reading: _____
Reference Temperature (Ambient Air Temperature) Reading: ______
Hydrolab Thermometer: Reference Temperature (0^0C - Ice/Water in ice chest) Reading: _____
Reference Temperature (Ambient Air Temperature) Reading: ______

FLOW RATE (Meter Make & ID):
__ gauging sheet attached
__ measured with bucket & stopwatch @ ______(volume) per ____(seconds) = ___liters/sec
__ other method - describe

SAMPLE CONTAINERS FILLED AT THIS SITE (**"*"** Collect Field Duplicate, Mark spaces "**x**" as Collected)
___ ___* 1L (plastic) no chemical preservation for TSS, TDS, Sulfate, Chloride, Acidity, Alkalinity.
____ ____* 250 mL (plastic) preserved with sulfuric acid to pH<2 for Total phosphorous,(NO2+NO3)
____ ____* 40 mL (glass) preserved with sulfuric acid to pH <2 for Total Organic Carbon.
____ ____* 40 mL (glass), filtered, preserved with sulfuric acid to pH <2 for Dissolved Organic Carbon.
____ ____* 500 mL (plastic) preserved with nitric acid to pH <2 for total metals and mercury.
____ ____* 250 mL (plastic), filtered preserved with nitric acid to pH <2 for dissolved metals.
____ No Dup. 250 mL (plastic) preserved with nitric acid to pH <2 for dissolved metals **(Filter Blank, 1/day per crew)**.
____ No Dup. 40 mL (glass) preserved with sulfuric acid to pH <2 for Dissolved Organic Carbon **(Filter Blank, 1/day/crew).**

FIELD FILTRATION
The plastic syringe will be used to suck up a sample from the stream. A new disposable 0.45 micron filter will be screwed on to the syringe and the sample will be filtered into the sample container for shipment to the laboratory. A new syringe and filter will be used at each sample site. The field filtering will comply with the requirements of 40 CFR Part 136, Table IB, note 4. **Filter blanks** will be prepared with lab pure water poured into filtering syringes, dispensed through the filter into the container, and acidified (acid listed above).

Chain of Custody:
Sampler Signature______________ Date (dd/mm/yy)_____ Time (military)____Hours
Place the above listed samples in the shipping container and seal them for shipment to the lab.

Lab Representative Signature________________. Received the above listed samples into the Laboratory custody on Date (mm/dd/yy) ________Time (military) _____ Hours.

FIELD SHEET - FLOW MEASUREMENT

STATION NUMBER _____________LOCATION_______________________________________
DATE mm/dd/yy ____/_____/______TIME (military) _____________________ hours
INVESTIGATOR(S)____
AGENCY ____

Distance From Bank	Depth of Water	Depth of Reading	Velocity

OBSERVATIONS: (over if required)

ATTACHMENT 3

INFORMATION ON PARAMETERS MONITORED

Information on Parameters Monitored				
Parameter	**Method ***	**"Frequency of Collection**	**Sample Preservation/Holding Time (ice to < 4C,acid to pH<2)**	**Method Detection Limits** (ug/l)**
Flow Rate	USGS stream gaging protocol modified to use electromagnetic velocity meter	On each sampling occasion at all 37 sites	not applicable	not applicable
Temperature (°C),	***EPA 170.1*** ***{Hydrolab*** type multiparameter field meter, *in situ*. See Section D.**]**	On each sampling occasion at all 37 sites	not applicable, *in situ*	not applicable
Dissolved Oxygen*** (mg/l),	***EPA 170.1*** ***[Hydrolab*** type multiparameter field meter, *in situ**.* **See Section D.]** EPA 360.1 [in situ]	On each sampling occasion at all 37 sites	not applicable, *in situ*	not applicable (Capable of $\pm$ 0.2 mg/L*)
pH*** (su),	***[Hydrolab*** type multiparameter field meter, *in situ**.* ***See Section D.***] EPA 150.1 [in situ]	On each sampling occasion at all 37 sites	not applicable, *in situ*	not applicable (Capable of measuring +/- 0.2 SU*)
Conductivity (umhos/cm)	***[Hydrolab*** type multiparameter field meter, *in situ**.* ***See Section D.]*** EPA 120.1 [in situ]	On each sampling occasion at all 37 sites	not applicable, *in situ*	not applicable
Total Suspended Solids	EPA 160.2	Monthly	Ice/7 days	5000
Total Dissolved Solids	EPA 160.1	Monthly	Ice/7 days	5000
Acidity	EPA 305.1	Monthly	Ice/14 days	2000
Alkalinity	EPA 310.1	Monthly	Ice/14 days	4000
Sulfate	EPA 375.4	Monthly	Ice/28 days	10000
Nitrate+Nitrite	EPA 300.0 Unless acid preservative interferes	Monthly	Ice/H_2SO_4/28 Days	100
Total Phosphorous	EPA 365.4	Monthly	Ice/H_2SO_4 /28 Days	10
Total Organic Carbon	EPA 415.1	Monthly	Ice/H_2SO_4 /28 Days	1000
Dissolved Organic Carbon	EPA 415.1	Monthly	Field filtered **(see Appendix A)** Ice/H_2SO_4 /28 Days	1000

Information on Parameters Monitored				
Parameter	**Method ***	**"Frequency of Collection**	**Sample Preservation/Holding Time (ice to < 4C,acid to pH<2)**	**Method Detection Limits** (ug/l)**
Dissolved Metals Al, Fe, Mn	EPA 200.7	Monthly	Field filtered **(see Appendix A)** Ice/HNO_3 /6 months	100
Chloride***	EPA 300.0	Monthly	Ice/28 days	80000
Total K, Na	EPA 258.1, 273.1	Monthly	Ice/HNO_3 /6 months	1000
Total Al***,	EPA 200.7	Monthly	Ice/HNO_3 /6 months	250
Ca, Mg, Mn	EPA 200.7	Monthly	Ice/HNO_3 /6 months	100
Hardness	EPA 200.7 (Calculated from Ca + Mg) 2340B APHA	Monthly	Ice/HNO_3 /6 months	Not Applicable
Total, Cr, Zn	EPA 200.7	Monthly	Ice/HNO_3 /6 months	10
Total Ag	EPA 200.7	Monthly	Ice/HNO_3 /6 months	10
Total Cu	EPA 200.7	Monthly	Ice/HNO_3 /6 months	10
Total Fe***	EPA 200.7	Monthly	Ice/HNO_3 /6 months	500
Total Ni	EPA 200.7	Monthly	Ice/HNO_3 /6 months	10
Total Be***	EPA 200.7	Monthly	Ice/HNO_3 /6 months	40
Total As	EPA 200.7	Monthly	Ice/HNO_3 /6 months	5
Total Cd	EPA 200.7	Monthly	Ice/HNO_3 /6 months	5
Total Pb	EPA 200.7	Monthly	Ice/HNO_3 /6 months	5
Total Se***	EPA 200.7	Monthly	Ice/HNO_3 /6 months	2
Total Sb	EPA 200.7	Monthly	Ice/HNO_3 /6 months	5
Total Tl	EPA 200.7	Monthly	Ice/HNO_3 /6 months	5
Total Hg***	EPA 245.1	Monthly	Ice/HNO_3 /6 months	0.8

***Other equivalent 40CFR Part 136 Methods may be substituted in order to meet the needed Method Detection Limits listed.**

****The method detection limits listed are not critical if ambient levels are routinely measured at significantly higher levels. If the detection levels listed for WVWQSC analytes can not be achieved and the routine ambient levels are not detectable, the Project Officer must be notified.**

***** Denotes parameter with applicable West Virginia Water Quality Stream Criteria (WVWQSC) for aquatic life**.

ATTACHMENT 4

ELECTRONIC SPREADSHEET OF THE RESULTS OF THE STUDY